CLAIMS

What is claimed is:

1. An electrosurgical cutting system, comprising:

a) an electrically conductive blade, said blade having a first surface, a second surface opposite said first surface, and an edge where said first and second surfaces meet, said edge having an edge radius of curvature, wherein a predetermined length of said edge is a cutting portion for cutting biological tissue;

b) a first insulator on said first surface;

c) a second insulator on said second surface; and

d) a source of pulsed electrical energy electrically connected to said blade;

wherein said cutting portion has an in-plane radius of curvature that is at least 10 times larger than said edge radius of curvature along the entire length of said cutting portion.

2. The system of claim 1, wherein said edge radius of curvature is less than about 25 microns.

3. The system of claim 2, wherein said edge radius of curvature is less than about 10 microns.

4. The system of claim 3, wherein said edge radius of curvature is less than about 5 microns.

5. The system of claim 4, wherein said edge radius of curvature is less than about 1 micron.

6. The system of claim 1, wherein along said cutting portion said first and second insulators each have a thickness less than said edge radius of curvature.

7. The system of claim 1, wherein along said cutting portion said thickness decreases approximately linearly, within a tapering region, as said first and second surfaces approach said edge to define a blade tapering angle.

8. The system of claim 7, wherein said blade tapering angle is less than 45 degrees.

9. The system of claim 8, wherein said blade tapering angle is less than 30 degrees.

10. The system of claim 9, wherein said blade tapering angle is less than 15 degrees.

11. The system of claim 7, wherein said blade is submerged in a liquid medium, and wherein electrical pulses provided by said source are sufficient to vaporize and ionize said liquid medium along said cutting portion to form a vapor cavity encompassing said tapering region.

12. The system of claim 1, wherein said blade comprises Tungsten or Titanium.

13. The system of claim 1, wherein said source of pulsed electrical energy provides pulsed electrical energy with each pulse having opposite polarity than the previous pulse.

14. The system of claim 1, wherein said source of pulsed electrical energy provides pulses having a pulse duration between 10 ns and 10 μs.

15. The system of claim 14, wherein said pulses are grouped into bursts of said pulses, each of said bursts being separated by a burst interval greater than 1 ms during which no pulses are present.

16. The system of claim 15, wherein each of said bursts of pulses has a duration less than 10 ms, whereby thermal damage to said tissue is reduced.

17. The system of claim 16, wherein each of said bursts of pulses has a duration less than 1 ms.

18. The system of claim 17, wherein each of said bursts of pulses has a duration less than 0.1 ms.

19. The system of claim 1, wherein said source of pulsed electrical energy provides pulsed electrical energy in the form of a burst of pulses having a number of pulses and an energy of each pulse selected such that liquid adjacent to said cutting portion prior to application of the burst of pulses is, at some time prior to completion of said burst of pulses, vaporized along all of said cutting portion.

20. The system of claim 19, wherein a total duration of said burst of pulses is between 5 μs and 500 μs.

21. The system of claim 20, wherein said total duration is between 10 μs and 100 μs.

22. The system of claim 19, wherein any two time-adjacent pulses in said burst of pulses have opposite polarities.

23. The system of claim 1, wherein:

said cutting portion is at least 50 μm long; and

an electric field at said cutting portion varies by no more than 50% along the entire length of said cutting portion.

24. The system of claim 1, wherein pulses from said source have a pulse duration that is sufficiently long for generation of a streamer and spark discharge, and wherein

said pulse duration is sufficiently short to avoid generation of a high current arc discharge.

25. The system of claim 1, wherein said blade is submerged in a liquid medium, and wherein pulses from said source have a voltage selected such that a vapor cavity formed on said blade does not ionize until said vapor cavity extends to said first and second insulators.

26. The system of claim 1, wherein said blade and said first and second insulators are etched together during operation, whereby said edge radius of curvature remains substantially unchanged during operation.

27. The system of claim 1, wherein said blade is slidably mounted between said first and second insulators, whereby said blade can be extended to compensate for erosion of said blade during operation.

28. A method for pulsed uniform cutting of biological tissue along a cutting zone of an electrode while immersed in a liquid medium, the method comprising:

a) delivering a burst of electrical pulses to said electrode to form a uniform vapor layer surrounding the cutting zone of the electrode, wherein a first vapor cavity forms in a high field region of said electrode, and wherein said electrical pulses do not ionize said first vapor cavity, and wherein said burst of electrical pulses then continues to vaporize said liquid medium in regions of

lower electric field until said uniform vapor layer is completely formed along the whole cutting zone before said first vapor cavity collapses; and

b) ionizing said uniform vapor layer resulting in uniform plasma-mediated discharge into said biological tissue contacting the vapor layer.

29. The method of claim 28, wherein a total duration of said burst of pulses is less than 10 ms, whereby thermal damage to said tissue is reduced.

30. The method of claim 29, wherein said total duration of said burst of pulses is less than 1 ms.

31. The method of claim 30, wherein said total duration of said burst of pulses is less than 0.1 ms.

32. The method of claim 28, wherein said pulses have a pulse duration between 10 ns and 10 μs.

33. The method of claim 28, wherein each pulse in said burst of pulses has opposite polarity than the previous pulse.

34. The method of claim 28, further comprising repetitively performing said delivering a burst of electrical pulses, wherein any two time-adjacent bursts are separated by a burst interval greater than 1 ms during which no pulses are present.